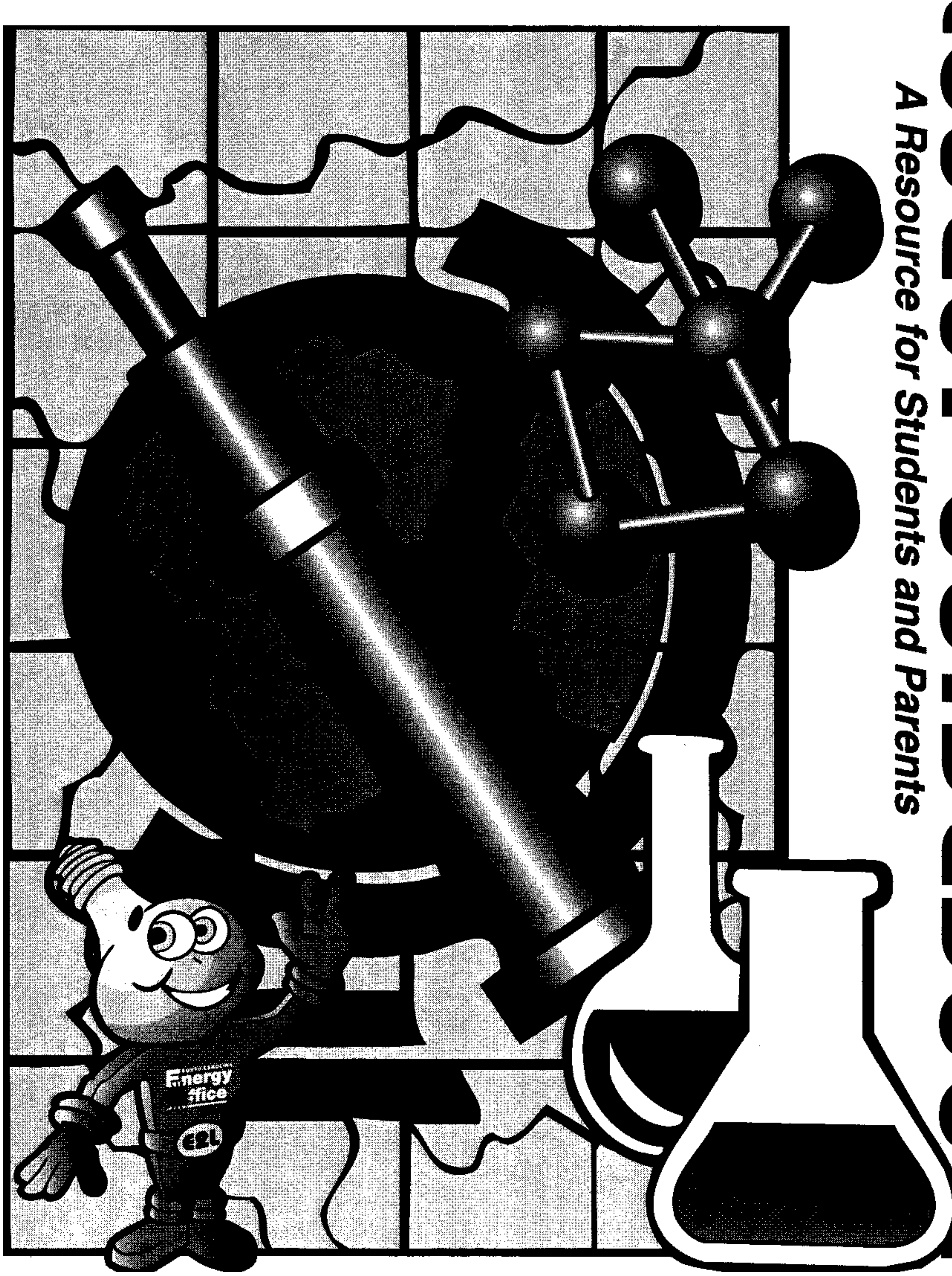
SCIENCE FAIR PROJECT GUIDEBOOK

A Resource for Students and Parents



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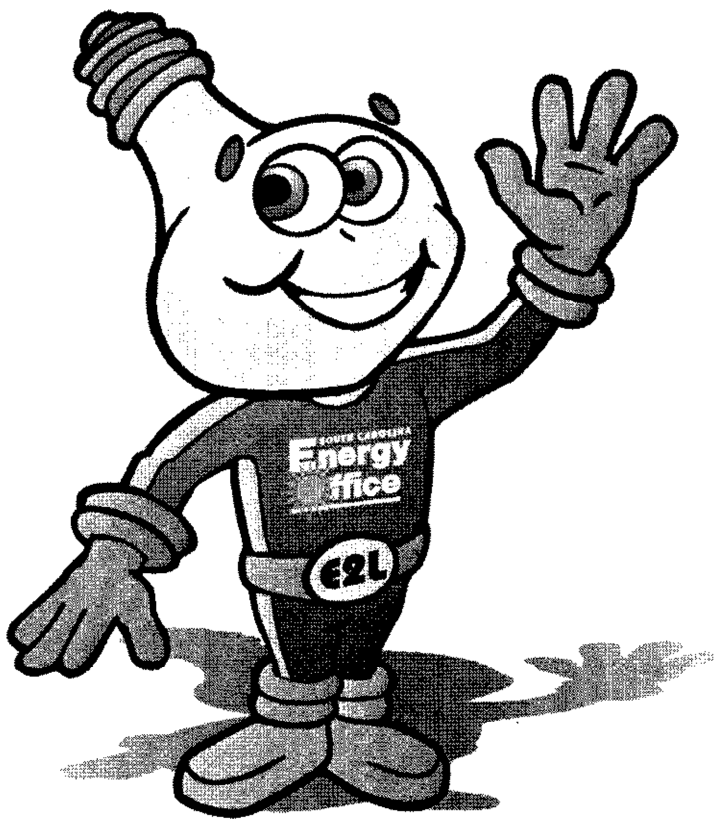

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Acknowledgements

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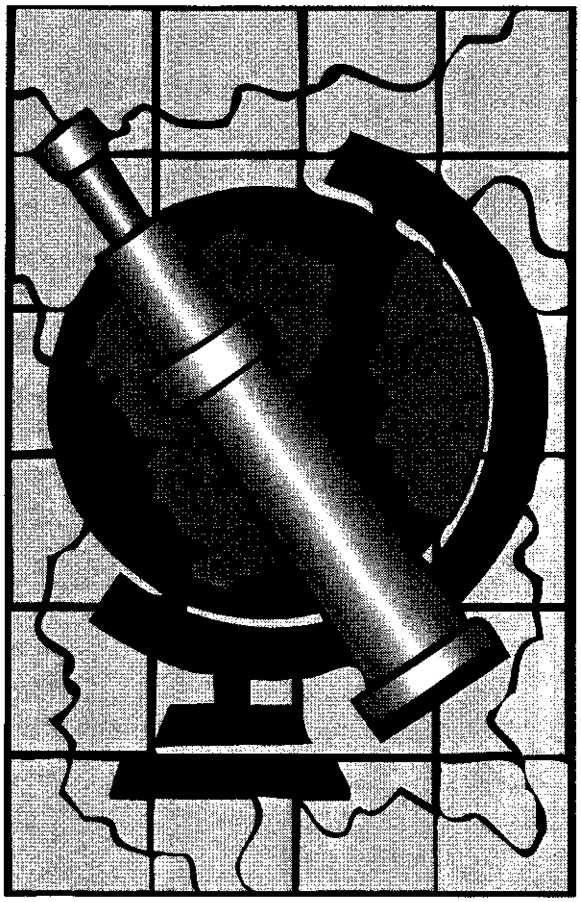
Thank you to "The Best of Edison" Science Teaching Kits for permission to use experiments on pages 8 through 14.

Thank you to Mary Spruill and the National Energy Education Development Project, NEED, for permission to use experiments on pages 15 through 22.

Introduction

It seems that nothing strikes fear in the hearts of students and parents like these three words: science fair project.

But it doesn't have to be that way. A science fair project is an opportunity to research and learn about things that interest you. And through your studies you will learn how science is basic to everything around us.



You will benefit beyond your improved science knowledge. Science fair projects teach you problem-solving skills, improve your written and oral communication ability and give you the satisfaction of completing a well-done project.

The ideas for projects are endless; you are limited only by your imagination. For example, does dirty dish water affect the growth of plants? Or how does acid rain affect plant growth? Which diapers are the most absorbent? What is the pH of various shampoos? Do different brands of gasoline make a difference in gas mileage?

The first key to a successful science fair project is picking a topic that interests you. The reason is simple: you will be motivated to do a better job on the project and will have fun doing it. And remember, a good science fair project doesn't have to be complicated. It is important that you understand your project and that you have explored the scientific and technical issues related to your project.

The second key is careful planning. After discussing your project with your teacher and getting approval for your idea, allow yourself plenty of time for research, experiments, observation and analysis. In other words, don't wait until the last minute. Projects take time.

Ask questions about your project, but do the work yourself. If you do the work yourself, you will get a much better understanding of why things do and do not work as expected.

Finally, don't get upset if your experiments prove your hypothesis incorrect. Throughout history, some of the most important experiments were those that didn't prove the original hypothesis.

On the following pages are basic ingredients for a science fair project and tips for a great display. There are also 10 ideas for science projects showcasing different forms of energy. We have come to rely so heavily on energy that we would be quite lost without it. The energy we rely on most today is non-renewable, and will run out eventually. It is important that we learn about renewable energy - energy that will last forever. These sources can be found all around us in water, the sun, natural gas, wind and other forms that have not yet been harnessed. Who knows, by performing one of the energy science projects in this book, you may unlock the secret of a new energy source for the future.

Good luck.

What is a Science Fair Project?

A science fair project is an investigation of a question that involves research, planning and application of the scientific method to find the answer.

The Scientific Method

The scientific method is a tool that scientists use to find answers to questions. The tool involves the following steps: doing research, identifying a problem, stating a hypothesis, conducting project experimentation, and reaching a conclusion.

Research

Your research begins when you select your project topic. Once you have chosen your topic, you'll begin your project research. HERE'S A TIP: Choose a catchy title. Make it specific. Usually, it's best for the title to be a question or something like this:

- The Effects of...
- The Study of...
- An Investigation of...
- A Comparative Study of...
- The Observation of...

Tips on How to Choose a Science Fair Project

- List your favorite activities and subjects. Now, select a project from one of those areas.
- What are some of the materials you could use with your experiment? Are the materials available at your home? You may want to select materials that are inexpensive and easy to find.
- Your school library and local public library are good places to go for more information to complete your science fair project.

Problem

The problem is the question to be answered.

Hypothesis

The hypothesis is simply your best guess as to what will happen.

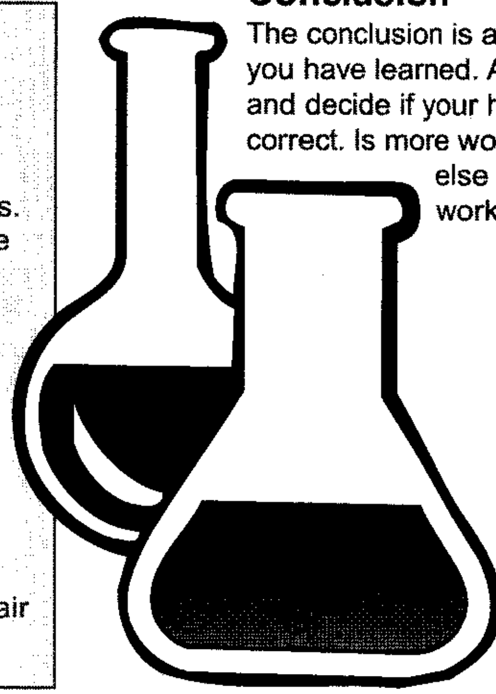
Project Experimentation

Project experimentation means testing your hypothesis. This includes more research - designing and planning for experimentation and testing. Test your hypothesis carefully by experimenting. Record everything you do. Make observations and record the results. Make charts and graphs or take pictures so others can understand what you have done.

Things that can affect your experiment are called variables. The independent variable is the variable you purposely change. The dependent variable is the variable you are observing that changes in response to the independent variable. The variables that are not changed are called controlled variables.

Conclusion

The conclusion is a summary of what you have learned. Analyze your data and decide if your hypothesis was correct. Is more work needed? What else would you do to work on this problem?



Helpful Web Sites for Your Science Fair Project

**Bill Nye, The Science Guy:
Episode Guide**
http://nyelabs.kcts.org
First, click on the ENTER button; select the TEACHERS' LOUNGE; then click on EPISODE GUIDES.

**Discovery Channel School:
Science Fair Central**
http://school.discovery.com/sciencefaircentral/

ISEF 2000
www.isef2000.org
This site provides all kinds of valuable information, including mandatory science fair project rules and guidelines.

**The Internet Public Library:
A Science Fair Project Resource Guide**
http://www.ipl.org/youth/projectguide/

**Cyber Fair:
Steps to Prepare a Science Fair Project**
http://www.isd77.k12.mn.us/resources/cf

The Kids Guide to Science Fair Projects
http://setmms.tusd.k12.az.us/~jtindell/

S.C. DHEC's Office of Solid Waste Reduction and Recycling
www.scdhec.net/recycle

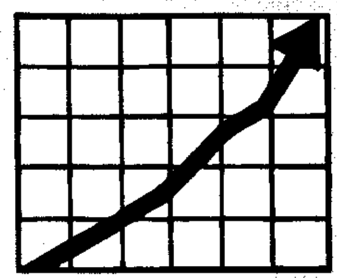
S.C. Energy Office
www.state.sc.us/energy

Science Project Guidelines
http://atlas.ksc.nasa.gov/education/general/scifair.html

Science Fairs Home Page
http://www.stemnet.nf.ca/~jbarron/scifair.html

Tips for a Great Display

- Check with your teacher to see if your school has any specific guidelines on the size, style or shape of the display.
- Keep the display simple - include only the essentials.
- Let the headlines tell the story - no lengthy descriptions.
- Check your spelling.
- When possible, use color to clarify information (charts, diagrams and graphs).



- Use photographs or drawings to help show what was done.
- Make the display as neat as possible. If you have access to a computer to make charts, graphs and labels - that's fine. If you don't, you can still make an attractive, neat and effective display. Use a stencil and ruler if possible. If you have to use a pencil, carefully go over the pencil lines with a dark marker.
- Let the teacher or science fair chairperson know early if the display needs electricity or other special arrangements.
- Use safe, durable materials. Make sure anything used in the display meets school safety standards.
- Have magazine articles, brochures and other materials to place in front of your display.

The Experiments: Part I

The following projects are provided by the Charles Edison Fund: A Philanthropic Foundation. They are recommended for use in **Grades 4 - 5**. These projects are from their booklet, "The Best of Edison" and are reprinted with permission.

Hot Water

Making water hot takes energy...lots of it. A typical family uses 15-20 million Btus of energy each year to heat water for washing everything from hands to dishes. It takes about 168 gallons of fuel oil, 19,900 cubic feet of natural gas or 4,500 kilowatt-hours of electricity to do the job.

The next two experiments have an important thing in common: they both show us how we may be wasting energy unintentionally.

Project #1: Should You Shower or Take a Bath?

MATERIALS:

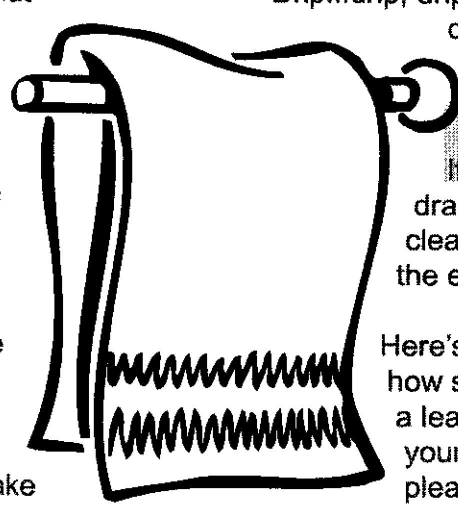
- Your Bathtub
- 1 Yardstick
- 1 Bar of Soap (optional)

Here's a surprising fact. If people who took baths took showers instead, we'd save a lot of energy. This experiment demonstrates what we mean.

Start by taking a bath. Fill your bathtub with water as usual, but before you step in, use your yardstick to measure the depth of the water in the tub.

Next, take a shower (better wait until you really need one!). Before you begin, though, do something unusual. Close the bathtub drain so the shower water will collect in the tub. When you are finished (take your time!), measure the depth of the water that has collected. Compare this reading with the bath water depth.

You will find that your shower used substantially less water...probably less than half as much! A lot of this water is hot water. As a rule of thumb, figure that it takes an ounce of oil (or a cubic foot of gas, or 1/4-kilowatt-hour of electricity) to heat a gallon of water. So you can see that showering saves lots of energy.



Project #2: A Little Drip Means a Big Energy Waste

MATERIALS:

- An Eight-ounce Graduated Measuring Cup
- 1 Pencil
- Paper
- 1 Faucet
- 1 Clock

Drip...drip, drip...goes the leaky faucet. Each drop of water is tiny, but add all the drops together and you end up with thousands of gallons of water dripping from the faucet each year. If hot water is dripping down the drain, you are wasting more than clean water...you are throwing away the energy used to heat that water.

Here's an experiment that shows you how serious the problem is. If you have a leaky faucet, use it. Otherwise, adjust your kitchen sink faucet (cold water, please) to produce a steady drip...drip...drip.

Place the measuring cup underneath the dripping faucet, and collect 15 minutes worth of drips. You might, for example, collect four ounces of water in 15 minutes.

Now you have to do some arithmetic to find out how much energy was wasted. Get your pencil and paper (and your thinking cap). We'll use the four-ounce figure in the example below:

- **Step 1:** Multiply the number of ounces of water you collected by 4 – this gives you the number of ounces per hour leaking through the faucet.

  4 ounces X 4 = 16 ounces per hour

- **Step 2:** Multiply the answer from Step 1 by 24 – this gives the number of ounces per day leaking through the faucet.

  16 ounces per hour X 24 = 384 ounces per day

- **Step 3:** Multiply the answer from Step 2 by 365 – this gives the number of ounces per year leaking through the faucet.

  384 ounces per day X 365 = 140,160 ounces per year

- **Step 4:** Divide the answer from Step 3 by 128 – this gives the number of gallons per year leaking through the faucet.

  140,160 ounces per year ÷ 128 = 1,095 gallons per year

That's a lot of water. And if it was hot water dripping, it took a lot of energy to make it hot. You can figure out approximately how much oil, gas or electricity was wasted by doing the following calculations:

- **For an oil-fired water heater:** Divide the answer from Step 4 by 110 – this gives the approximate number of gallons of oil wasted.

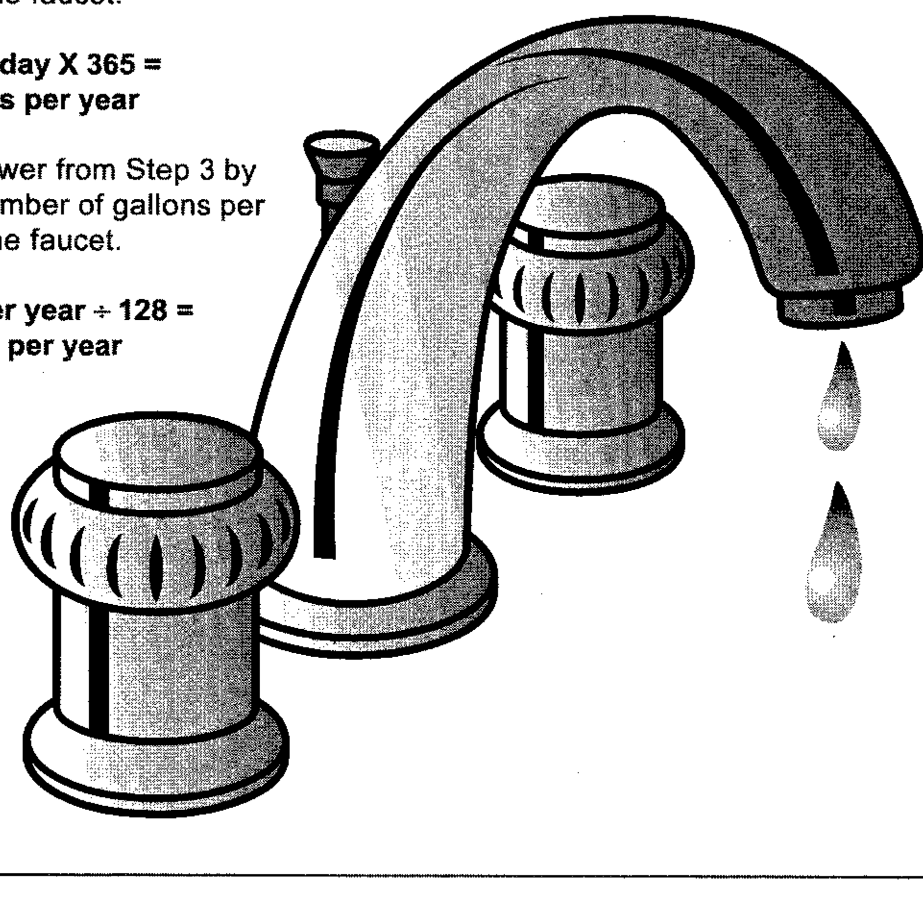
  1,095 ÷ 110 = 9.95 gallons of oil per year

- **For a gas-fired water heater:** Multiply the answer from Step 4 by 1.2 – this gives the approximate number of cubic feet of gas.

  1,095 X 1.2 = 1,314 cubic feet of gas per year

- **For an electric water heater:** Multiply the answer from Step 4 by 0.25 – this gives the approximate number of kilowatt-hours of electricity wasted.

  1,095 X 0.25 = 274 kilowatt-hours per year



Heating and Air Conditioning

Here's an interesting fact. A typical American family uses more energy to heat their home in winter than for any other purpose except powering their automobile. "Space heating" (that's the technical term) uses more than one-fourth of an average family's total energy budget. That's more than 100,000,000 Btus! It's equivalent to more than 800 gallons of oil or 100,000 cubic feet of natural gas.

The following experiment will teach you a lot about keeping heat where you want it...which, after all, is the secret of conserving energy used for space heating. You see, during the winter, you want to keep heat *inside* your home. The better job you do, the less fuel you have to burn.

If your home is air conditioned, the same thing is true...in reverse! During the hot summer months, the idea is to keep the heat *outside*. By doing this, you cut down on the energy needed to run your air conditioner.

Project #3: How Does Insulation Work?

MATERIALS:

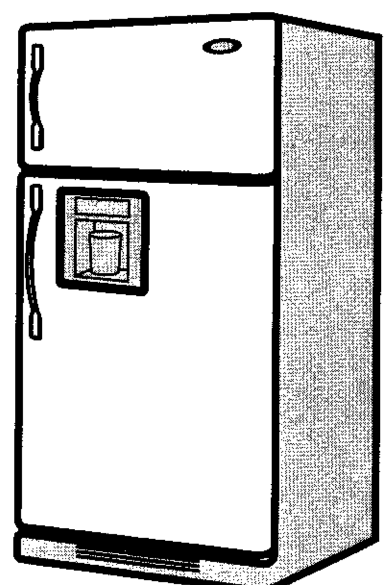
- 1 Small Water Glass
- 1 Inexpensive "Fish Tank" Thermometer
- 1 Cardboard Box *(find one made out of corrugated cardboard; it should be just big enough to hold the water glass)*
- 1 Handful of Cotton Balls

During the winter, the insulation in your home's walls slows down the movement of heat from indoors to the cold outdoors. To understand how insulation works, you must first study how quickly heat will flow from a warm object to cold air when no insulation is present.

Fill the glass with water that is at room temperature (about 70°F); use your thermometer to measure the exact temperature. Put the thermometer into the glass, then place the glass inside your refrigerator. Check the water temperature every five minutes.

You will find that the water temperature drops quickly...probably three or four degrees every five minutes. The reason, of course, is that heat is flowing out of the relatively warm water and into the relatively cold surrounding air inside the refrigerator.

Now let's add some insulation. Here's how. First, refill the glass with water at room temperature. Then, place a layer of cotton balls inside the bottom of the cardboard box, and rest the glass on top of the layer of cotton. Finally, pack the empty space between the glass and the sides of the box with cotton balls. Put the thermometer in the glass and measure the exact temperature. Place the glass, cotton and box in the refrigerator and the temperature every five minutes. You'll find that the temperature will drop much less quickly this time...maybe only a degree or so every five minutes. The cotton insulation is slowing down the loss of heat from the water in the glass.



The insulation in your home's walls is not made of cotton (it is probably made of fiberglass), but it works much the same way.

You may be surprised to learn that many homes are poorly insulated – they have no insulation in their walls and ceilings, or too little to effectively slow down the movement of heat from inside to outside. Because of this, their owners must burn more fuel in order to stay warm. This is a major cause of energy waste.

Appliances and Lighting

The next chance you get, go on a "scavenger hunt" around your home for things that use energy. You'll probably find several dozen electric lights (don't forget the bulb inside your refrigerator!), a dozen or more different appliances (refrigerator, TV, toaster, washing machine, etc.), a few electric clocks, a stereo and maybe even an electric toothbrush.

It has been estimated that a well-equipped home consumes more than 35,000,000 Btus of energy each year keeping these "energy eaters" well fed.

A lot of this energy is wasted. That's bad news. But here's the good news: It's easy to conserve much of the energy we are currently wasting.

ELECTRICAL APPLIANCE ENERGY TABLE

Appliance Wattage Rating	Kilowatt-Hrs. of Energy Used Hourly	Ounces of Oil Burned Hourly	Ounces of Coal Burned Hourly
10	1/100	1/10	13/100
25	1/40	1/4	33/100 (or 1/3)
40	1/25	2/5	1/2
60	3/50	3/5	4/5
110	1/10	1	1 and 1/3
150	3/20	1 and 1/2	2
200	1/5	2	2 and 2/3
300	3/10	3	4
500	1/2	5	6 and 2/3
750	3/4	7 and 1/2	10
1000	1	10	13 and 1/3
1500	1 and 1/2	15	20
2000	2	20	26 and 2/3
5000	5	50	66 and 2/3

The following two experiments will turn you into an energy-saving expert. But before you begin, let's spend a few moments discussing how you can determine how much energy each of the electrical appliances in your home uses. It's really very easy. All you have to do is look on the back or bottom of the appliance to find the electrical "ratings" information. You will see a group of numbers pretty much like the numbers in the chart on this page.

Ignore all the numbers *except* the wattage rating. This number is the key to energy consumption.

Once you have an appliance's wattage rating, consult the table on the left. It tells you how much electrical energy (measured in kilowatt-hours) the appliance consumes during *one hour* of operation. The table also tells you roughly how much oil or coal was burned at your power station to produce this amount of electrical energy.

Be sure you ask for permission before you turn over any kitchen appliances, and don't try to move big appliances without help from an adult.

Project #4: Does Your Clothes Dryer Waste Energy?

MATERIALS:

- About an Hour of Spare Time on Washing Day
- 1 Clock

The heart of a clothes dryer is a source of hot air. Wet clothes tumble through the hot air and are dried. It takes many thousands of Btus of energy per hour to heat the air – so we should never run a clothes dryer unnecessarily.

However, many people do just that. They set the dryer's timer for longer than is necessary, and the machine rumbles on long after the clothes inside are completely dry.

This simple experiment will tell the tale. Start by getting permission. Learn how to restart the machine after you stop it by opening the door. Now you are ready to begin.

The next time there is a load of clothes in the dryer, pull up a comfortable chair and start watching the clock. After fifteen minutes goes by, open the dryer door, wait for the drum to stop turning, then feel the clothes (careful...they may be hot). They will probably still be damp. Close the door and restart the dryer.

Do this again every five minutes until the clothes feel dry to your touch. Look at the timer and see how much longer the dryer was set to run. If your dryer is electric, you can figure that every wasted minute burned about 4/5 ounce of oil (or one ounce of coal) back at the power company. If your dryer runs on gas, figure that every wasted minute burned about 1/10 cubic feet of gas.

Here are two other energy-saving tips for dryers:

- Make sure the lint filter is cleaned every time the dryer is used.
- Don't dry "half loads" – make sure the machine is full before using it.

Project #5: Checklist for Energy – Efficient Lighting

MATERIALS:

- 1 Yardstick or Tape Measure
- 1 Pencil
- Paper

How much energy is used to light your home? Your household probably uses about 2,000 kilowatt-hours of electrical energy each year. Your local electric power plant burns about 150 gallons of oil (or more than 3/4 ton of coal) to generate that much electricity.

With this much energy "going up in light," it makes good sense to learn to use lighting efficiently. This simple lighting checklist will give you a head start. Walk through your home – with pencil and paper in hand – and see how well the lights in your home measure up. Tell your parents about your findings.

Are bulbs and lampshades free of dust and dirt that block light transmission? Dirty bulbs and shades waste the light produced inside the bulbs. As a result, you may turn on two lights when only one is really necessary.

Are lampshades translucent (so light can pass through them) rather than solid? It doesn't make sense to use energy to produce light and then block the light with a solid lampshade.

Are ceilings and walls light-colored? Light colors reflect more light than dark colors, so fewer lamps (or lower-wattage bulbs) can be used to light the room.

Are "non-critical" lighting levels in your home kept as low as possible? As a rule of thumb, one watt of lighting per square foot of floor area is adequate for general room and hallway lighting. Use your yardstick or tape measure to measure the floor space of rooms and halls. Check the wattage of the bulb(s) in the room to see if the lighting level is too high. For example, a 100-watt bulb in a 50-square-foot hall is too much. Of course, "critical" tasks (such as reading, sewing, building model airplanes and doing your homework) require more light.

Does every member of your family turn off lights after he or she leaves a room? Not doing this is an out-and-out waste of valuable energy!

You may hear some people say they purposely leave lights on. These people mistakenly believe that the sudden surge of electricity that flows through a light bulb when it is turned on represents a lot of energy. They think keeping the bulb lit – and thereby avoiding starting surges – somehow saves energy. They are wrong. A light bulb consumes less energy during its starting surge than during a single second of normal operation. Always turn lights off when they are unnecessary, even if it's only for a few seconds.

Energy From Trash

Turn trash into energy? Yes indeed. Many cities across the United States are doing just that. The idea makes good sense.

After you complete this project, you will see that much of the waste we discard every day can be burned to produce heat. In turn, this heat can be used to generate electricity in a power plant.

But combustible materials are only part of the story. We also discard organic wastes (such as food scraps) that can be transformed into methane gas, the main component of natural gas. In this way, our garbage can help supplement America's natural gas supply.

According to the U.S. Environmental Protection Agency, more than 6 billion tons of waste of all kinds are produced in America each year. A large portion of this mind-boggling heap contains recoverable energy that never gets recovered. That's a lot of energy going to waste...in waste.

As you might expect, converting waste products into energy is an expensive process, particularly when it is done on a large scale. However, waste conversion kills two birds with one stone. First, it provides us with needed energy. Second, it save valuable landfill space. For both of these reasons, many experts predict waste conversion will become very popular in the years ahead.

Project #6: Turning Trash into Usable Energy

MATERIALS:

- A Pair of Gloves
- Household Trash (see text)
- A Shallow Baking Dish
- Aluminum Foil

As we said earlier, many of the things we throw away every day can be burned to produce heat. They are a source of energy. This simple experiment proves the point. It shows one way of converting trash into fire fuel.

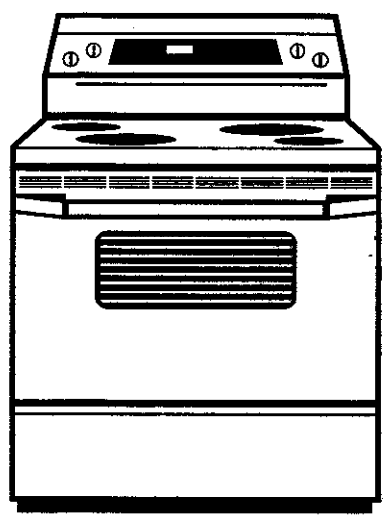
The first step is to put on a pair of gloves and rummage through your trash cans. Look for paper or cardboard items that aren't too dirty or messy. For example:

- Paper cups or plates;
- Paper toilet tissue wrappers;
- Paper towels; and
- Flour or sugar bags.

You get the idea...the list can go on and on.

Using scissors, cut these items into pieces that will fit neatly into the baking dish. But don't put them into the dish yet. First soak them in warm water until they are soggy. While the paper pieces are soaking, line the dish with aluminum foil to keep it clean.

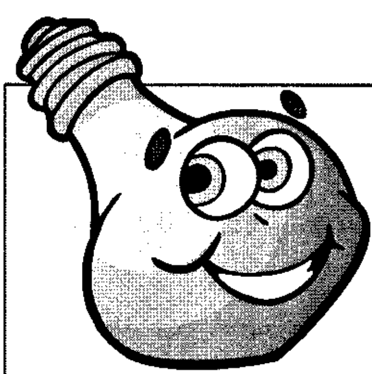
Then place layer after layer of soggy paper into the dish. Use your fingers to press the layers together and to force the excess water out of the soggy mass. Pour this excess water out. Stop adding layers when you've built a pile that's about 3/4 inch thick.



Now we want the compressed pile to dry out. For this demonstration only, let's speed up the drying process by using an oven (better check to see if it's OK to use the oven for this purpose). Bake the pile for about an hour. The oven temperature should be around 200°F. DON'T USE A MICROWAVE OVEN. Because of the aluminum foil, the microwave tube inside the unit could be damaged.

After taking the dish out of the oven and letting the contents cool down, lift the pile out of the dish. If it is still damp, set it aside until completely dry. When dry, chunks of this salvaged waste paper will burn like wood. You can use them in a fireplace, campfire, or wherever.

When making additional piles, skip the oven part. (You don't need the baking dish either; use something else.) Simply let the piles dry outside in the aluminum foil liner. It doesn't make sense to consume more energy using the oven than you get from the fire fuel.



Here's an IDEA...

Before you begin a project, ask your teacher which categories will be judged at your regional science fair competition.

The Experiments: Part II

The following projects are provided by the National Energy Education Development Project, NEED. They are recommended for use in **Grades 7 - 12**. These projects are from NEED's "Science of Energy" booklet and are reprinted with permission. They have been modified for use in this guidebook.

Exploring Thermal Energy

The following experiments investigate *exothermic reactions* (reactions that produce heat) and *endothermic reactions* (reactions that use heat).

Project #1: Endothermic Reactions

MATERIALS:

- 1 Bottle of Vinegar
- 1 Container of Baking Soda
- 4 Empty Plastic Sandwich Bags
- 1 Thermometer
- 1 Spoon

PREPARATION:

- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.

PROCEDURE:

- Explain that you are going to mix two chemicals together to make a third chemical. The reaction is an endothermic reaction – it requires energy in the form of heat to make the third chemical from the first two.
- Pour about an ounce of vinegar into an empty plastic sandwich bag.
- Feel the vinegar in the bag to note the temperature. Measure the exact temperature using the thermometer.
- Record the temperature of the vinegar. Leave the thermometer in the bag.
- Carefully pour about a teaspoon of baking soda into the bag with the vinegar. Be careful – the reaction will foam to the top of the bag.
- Watch the temperature on the thermometer drop. It should drop about 5 degrees Centigrade in 30 seconds.
- Record the time and temperature and remove the thermometer from bag.
- Feel the bag again to note the temperature.
- Carefully zip bag and put it aside.

ORAL PRESENTATION

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

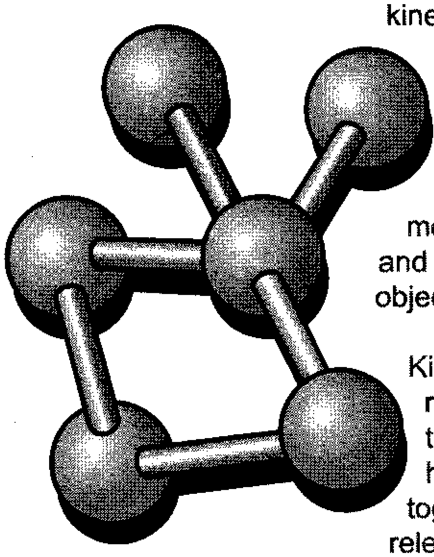
During this experiment, you'll be learning about chemical reactions. Chemical reactions occur when you mix two [or more] chemical compounds together to form other compounds. All chemical reactions involve heat. Some give off heat and some use heat.

An endothermic reaction uses heat. *Endo* means *in* and *thermal* means *heat.* Endothermic – the heat goes in. Since the easiest way to measure heat is by its temperature, we'll use a thermometer to show the changes in heat.

This experiment is an endothermic reaction – it uses heat. I'm going to mix vinegar and baking soda together to make another chemical. First, I'll add the vinegar and check the temperature of it. [Pour about an ounce of vinegar into an empty plastic bag. Hold the bag at the top and tilt it so that all the vinegar is in one corner. Take the temperature of the vinegar. It should be about room temperature. Let everyone touch the bag.] It is ______ degrees.

Everyone touch the bag so you'll know what the temperature feels like. Now I'm going to add the baking soda. You'll be able to see a reaction taking place. [Leave the thermometer in the bag. Pour in about a teaspoonful of baking soda. Be careful; the reaction will foam very high.] Now, watch the temperature on the thermometer. [The temperature should drop four to five degrees Centigrade in 30 seconds. Let everyone touch the bag again.] The temperature has dropped about four to five degrees. Now touch the bag and tell me how it feels. Do you feel the difference?

It feels colder because the reaction we just saw uses energy. [Take thermometer out of bag. Zip up bag and put to the side with the vinegar and baking soda.] Heat is a form of kinetic energy – the vibration of molecules. The more heat energy, the more the molecules vibrate and the hotter the object feels.



Kinetic energy is required to break the bonds that hold molecules together and is released when bonds are formed. [Show the formulas for endothermic reactions on page 17] The top equation shows the reaction of vinegar and baking soda. The reaction takes more energy to break the bonds than to form the new bonds. The reaction takes the energy it needs from the surrounding environment, which is why the bag feels colder. The second equation is photosynthesis – another endothermic reaction. Sunlight – or radiant energy – is needed to combine water and carbon dioxide to form more complex chemical compounds.

Project #2: Exothermic Reactions

MATERIALS:

- 4 Handwarmers
- 1 Sealed Bag of Iron Oxide
- 1 Container of Calcium Chloride
- 2 Empty Plastic Bags
- Scissors
- 2 Ounces of Water

PREPARATIONS:

- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.
- The sealed bag of iron oxide contains old filings from the handwarmers. This is called the old packet. A few minutes before your first presentation, cut open a new packet and pour it into an empty plastic bag. Keep the bag open so that oxygen in the air can react with the black powder. This is called the new packet.

PROCEDURE: HANDWARMERS

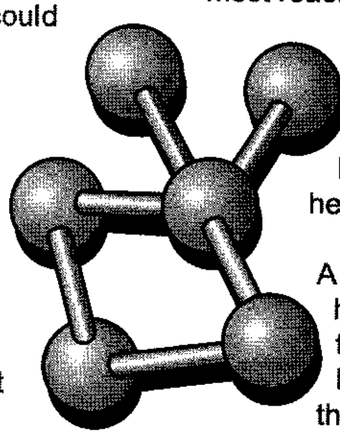
- Explain that you are going to let oxygen come into contact with pieces of iron to produce a third chemical – iron oxide. The reaction is an exothermic reaction – it produces energy in the form of heat. Most reactions are exothermic.
- Show the package that held the iron filings.
- Feel the new packet to note the temperature.

- Seal the new packet to prevent oxygen from entering the bag.
- Let students feel the old packet and note the temperature.
- After performing the second part of the demonstration – driveway ice – let students feel the new packet that you sealed, pointing out the temperature drop after the bag was sealed and no oxygen could enter to keep the reaction going.

PROCEDURE: DRIVEWAY ICE

- Explain that calcium chloride is used to melt ice on sidewalks and driveways. When calcium chloride comes into contact with water, a reaction takes place that produces heat.
- Pour two ounces of water into a plastic bag. Record the temperature using the thermometer.
- Pour a teaspoon of calcium chloride into the water.
- Record the temperature.
- Seal the bag and put it aside.

ORAL PRESENTATION:



Most reactions don't take in heat like vinegar and baking soda. Most chemical reactions give off heat – they're exothermic. *Exo* means *out* and *thermal* means *heat.* Exothermic – the heat goes out. Let's watch a reaction that gives off heat.

A few minutes ago I opened this handwarmer. It was filled with iron filings. [Show audience the package the hand warmer came in.] Why do you think it was sealed in plastic? [Get answers from audience.] The plastic keeps air from reaching the iron. I put the iron filings into this plastic bag and left it open so that oxygen could get to it. [Hold up new packet.] The oxygen

ENDOTHERMIC REACTIONS

VINEGAR AND BAKING SODA

Vinegar + Baking Soda + Heat → Water + Carbon Dioxide + Sodium Acetate

$CH_3COOH + NaCO_3 + \text{Heat} \rightarrow H_2O + CO_2 + NaC_2H_3O_2$

PHOTOSYNTHESIS

Water + Carbon Dioxide + Radiant Energy → Glucose + Oxygen

$6H_2O + 6CO_2 + \text{Radiant Energy} \rightarrow C_6H_{12}O_6 + 6O_2$

EXOTHERMIC REACTION

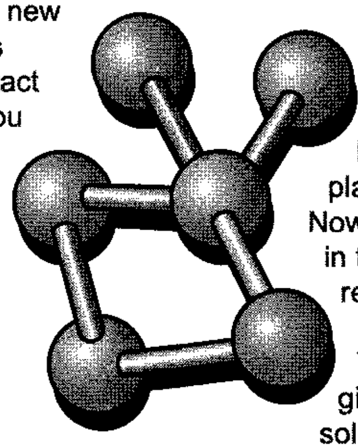
IRON FILINGS

Iron + Oxygen → Iron Oxide (Rust) + Heat Energy

$4Fe + 3O_2 \rightarrow 2Fe_2O_3 + \text{Heat Energy}$

in the air is reacting with the iron to form a new chemical, iron oxide, or rust.

Feel this packet. [Let everyone feel new packet. It should feel warm.] It feels warm. When oxygen comes in contact with iron, it makes rust and heat. You can see that most of the iron filings are still black. [Show the formulas for exothermic reactions on page 17] They will slowly turn to rust as long as we let oxygen reach them. Now, I'm going to seal the bag. No oxygen will be able to get to the iron filings. The reaction should slow down and stop. At the end of the presentation, we'll feel the bag again to see if the temperature has changed.



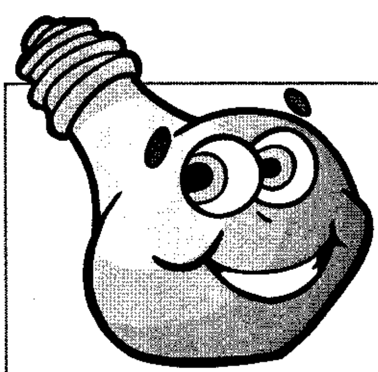
Here is a packet of filings that has been open for several weeks. [Hold up old packet. Let everyone feel it.] As you can see, all the iron has turned to rust. No more heat is being produced. Why do you think the handwarmer has a lot of iron filings instead of one chunk of iron? [Get answers from audience.] Because more iron can come in contact with oxygen when it is in small pieces.

Let me demonstrate another reaction. This container contains calcium chloride - it is used to melt ice on sidewalks and driveways. When calcium chloride comes in contact with water, a reaction occurs and heat is produced.

Let's put two ounces of water into this plastic bag and record the temperature. Now, let's put a teaspoon of calcium chloride in the water. Since this is an exothermic reaction, will the temperature of the water increase or decrease? [Get answers.] That's right. Since exothermic reactions give off heat, the temperature of the solution should increase. [Record temperature.] As you can see, the temperature of the water is now _____.

Feel the bag of iron filings that I sealed a few minutes ago. [Pass the new packet around.] The iron filings are cooler, aren't they? Sealing the bag kept oxygen from coming in contact with the iron. The reaction has stopped. No more heat is being produced.

Do you have any questions?



Here's an IDEA...

Save your old science fair project and expand on it each year.

Science Fair Project #3: The Apple Battery

This project examines electricity and transforming chemical energy into electricity.

MATERIALS:

- 1 Large Zinc Nail
- 1 Small Zinc Nail
- 1 Meter
- 1 Display Sheet (page 21)
- 1 Thick Copper Wire
- 1 Thin Copper Wire
- 1 Set of Tin Wire Alligator Clips
- 1 Apple

PREPARATION:

- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.
- Attach clips to the leads of the meter. Place the meter so the audience can see its face. If the needle of the meter seems to stick, gently tap the face of the meter.

PROCEDURE:

- Explain that you will be using the chemical energy in an apple to make electricity, as described in the script.
- Insert large zinc nail and thick copper wire into the apple about one centimeter, making sure they don't touch each other. Attach the clip with the green label to the zinc nail, the other clip to the copper wire. Point out the meter reading.
- Using the Display Sheet, explain to the audience how the acid in the apple reacts with metals to free electrons and produce an electric current.
- Push the nail and wire farther into the apple and point out the meter reading.
- Pull the copper wire out part way, then reverse the arrangement, noting the meter.
- Push the nail and wire into the apple so that they are touching. Point out that there is no current and explain why.
- Insert the thin copper wire and compare the meter readings of the copper wires with the nail.
- Attach the meter to the two copper wires and explain why there is no current.
- Insert the tin wire into the apple, along with the copper and zinc, making sure none of them touch. Explore the different combinations of metals.

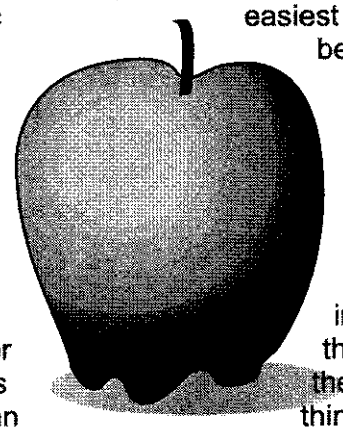
ORAL PRESENTATION:

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

Welcome to my power plant. I'm going to make electricity for you today. Most of the electricity we use today is made with turbine generators, but I'm going to use an apple and some pieces of different metals. I'm going to use the chemical energy in the apple to make electricity without a turbine.

Chemicals are everywhere. Take this apple, for example. [Hold up apple.] I'm going to use the malic acid in this apple to show how a battery works.

Here I have a zinc nail and a piece of copper wire. I'm going to push them into the apple. [Insert the large nail and thick copper wire about one centimeter into the apple, making sure they don't touch. Attach the clip with the green label to the zinc nail and the other clip to the wire.] Now I'm going to attach them to the meter, which detects electric current. As you can see looking at the meter, I've produced an electric current. The question is, why?



When I put the zinc and copper into the apple, both metals react with the acid. The acid frees many electrons from both metals. But they don't react exactly the same way. The metals lose electrons in different amounts. Let's say, to keep it simple, that for every two electrons the copper loses, the zinc loses four. This creates an imbalance. The copper becomes an electron donor. The zinc becomes an electron acceptor. [Show diagram on page 21.]

Since the zinc is losing more electrons than the copper, the zinc takes electrons from the copper to equalize the electric charge. So, electrons from the copper wire flow through the wires and the meter to the zinc nail. Look at the direction the needle on the meter is pointing. It shows that electrons are flowing from the copper to the zinc. This is the way all batteries work. There are chemicals in batteries and the electrons flow from one metal to another, converting chemical energy into electrical energy.

What will happen if I push the zinc and copper all the way into the apple? [Push both in about four centimeters, making sure they don't touch.] Look at the meter. There is more electric current, because there are more electrons free to move. Electricity is just moving electrons.

What will happen if only one metal is pushed in all the way? [Pull copper most of the way out.] Let's see. The current drops, doesn't it? There isn't as much copper to give up electrons. Let's try the opposite way, pushing in the copper and pulling out the zinc. Same result, right? Even if there's a lot of copper to give up electrons, there isn't a lot of current because there isn't a lot of zinc to accept the electrons.

This time I'm going to push both metals into the apple so they're touching each other. What do you think will happen? [Push copper wire and nail in so the ends touch inside the apple.]

No current is flowing through the meter. Does that mean there are no moving electrons? No, it just means the electrons are flowing straight from one metal to the other. Electrons always take the easiest path. This is called a short circuit, because the electricity is taking the shortest path.

Let's try something else. I'm going to put this thin copper wire into the apple, too, so we can compare the current. Which wire do you think will produce more current? [Put both wires and nail into apple about four centimeters so they aren't touching each other. Measure the current using the thick wire, then the thin wire.] First, let's measure the current of the thick copper wire. Now let's measure the thin wire. The thick wire produces more current, because it has more surface to come in contact with the acid.

What do you think will happen if I attach the two copper wires to the meter? [Attach copper wires to the meter.] Let's try it and see. There shouldn't be any current, should there? There is no metal producing electrons. Let's attach both zinc nails to the meter and see what happens. [Attach both zinc nails to the meter.] There is no current produced in this case either. There is no metal to accept the electrons that are freed from the zinc. There are no moving electrons.

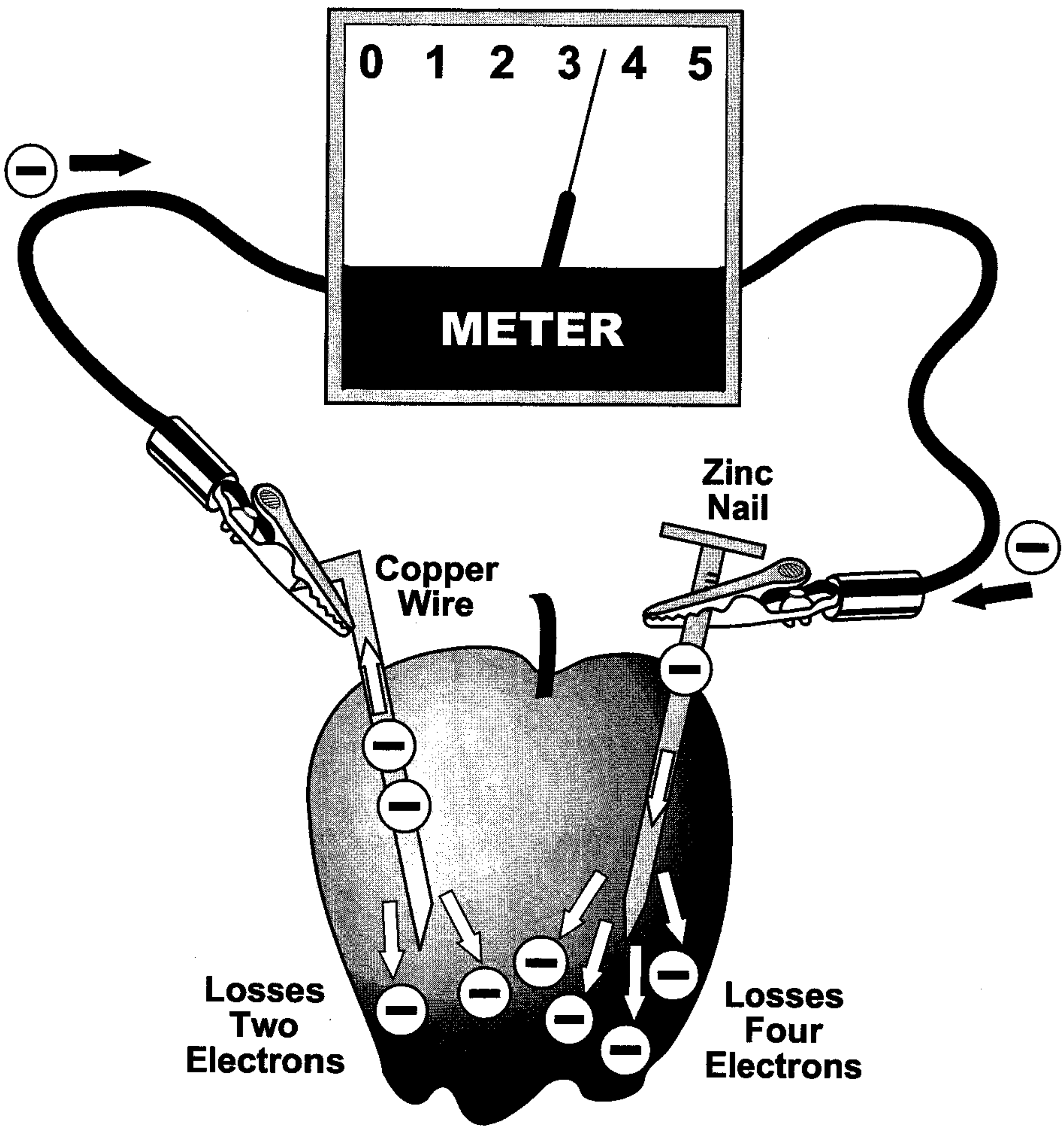
Now let's try a new metal – tin. Let's place all three metals into the apple to see if tin will be an electron donor or acceptor. [Insert large zinc nail, thick copper wire, and tin wire into the apple, making sure they don't touch.] When I attach the alligator clip with the green label to the tin and the other clip to the copper, you can see that tin is an electron acceptor.

When I switch the clip from the copper wire to the zinc nail, watch what happens. The needle moves the other way. That's because the tin has now become the donor. The combination of metals determines which metal will be the electron donor.

We have explored several ways an apple battery can convert chemical energy into electricity.

Do you have any questions?

Electrochemical Cell



Science Fair Project #4: Magnets

This project will explore *electricity* and *magnetism*. It will also investigate transforming mechanical energy into electricity.

MATERIALS:

- 1 Large Magnet
- 1 Small Magnet
- 1 Meter
- 1 Small Coil with Many Turns
- 1 Large Coil with Few Turns
- The Illustration on Page 23

PREPARATION:

- Study the sample script to learn the experiment.
- Examine the equipment.
- Practice your presentation.
- Attach clips to the leads of the meter. Place the meter so the audience can see its face. If the needle of the meter seems to stick, gently tap the face of the meter.

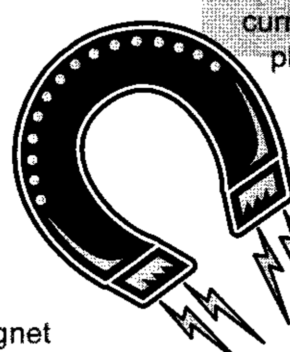
PROCEDURE:

- Using the illustration on page 23, briefly explain how power plants generate electricity.
- Connect the clips from the meter to the leads on the small coil with many turns. It doesn't matter which way you connect them.
- Slide the flat side of the large magnet back and forth over the coil several times, NOT TOUCHING THE COIL. Note the movement of the needle from side to side. Vary the speed with which you move the magnet and note the meter.
- Rest the magnet on top of the coil and note that no current is produced.
- Place the magnet on the table. Place the coil on it, then quickly pull it away. Note the meter.
- Rest the coil on the magnet. Move the magnet and coil together. Note that no current is produced.
- Demonstrate with both magnets to compare the strength of the magnet.
- Demonstrate with both coils, making sure to point out the difference in the number of turns of the wire.

ORAL PRESENTATION:

This script is just a sample. You don't need to say it word for word. The important thing is to get the major concepts and facts across to your audience.

There are lots of different ways to make electricity, but I'm here to show you how the pros do it. More than 160 years ago, Michael Faraday discovered that if you move a magnet through a coil of copper wire, you produce an electric current in the wire. All of our major power plants produce electricity this way. [Explain the illustration of page 23.]



Power plants use energy to spin a huge turbine. The turbine rotates a magnet in a coil of copper wire to produce electricity. Lots of different kinds of energy are used to spin the turbines. In most power plants, coal is burned to make steam. The steam is used to spin the turbines. Windmills use the mechanical energy in the wind to spin the turbines.

Today, I'm going to use my mechanical energy to make electricity. Here I have a coil of copper wire I am attaching to a meter that measures electric current. And here I have a magnet. [Attach the small coil with many turns to the meter. Place the large, flat side of the magnet over the top of the coil – near BUT NOT TOUCHING. Move the magnet back and forth over the coil several times.]

When I use my mechanical energy to move the magnet over the coil, I make electricity. Watch the meter – notice the needle jump from side to side. That means the current is alternating from one direction to the other. I'm producing an alternating current. It's called an AC current and it's the kind of electricity we use in our homes. The electricity you get from a battery is direct – or DC – current. That means it always flows in one direction. Batteries produce DC current.

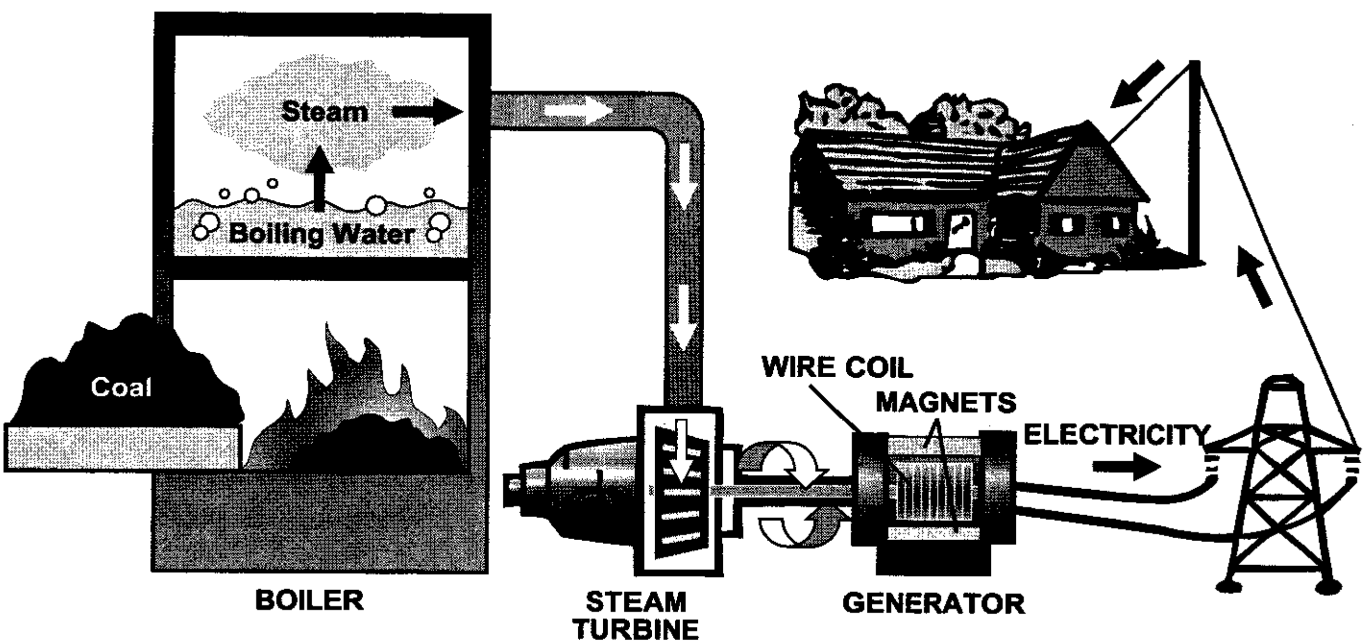
If I just rest the magnet on top of the coil, no electricity is produced. No mechanical energy is being used to make the electrical energy.

What do you think will happen if I put the magnet on the table and move the coil? Let's try it and see. [Place the coil over the magnet, then move it away several times.] It produces electricity. It doesn't matter whether we move the magnet or the coil, as long as one of them moves and the other doesn't. If I move both the magnet and the coil in the same direction at the same speed, no electricity will be produced. Watch. [Place the coil on top of the magnet and move them together.]

Let's see what we can do that affects the amount of electricity we produce. First, let's try speed. Do you think I can produce more electricity if I move the magnet quickly? First, I'll move the magnet slowly – let's see what the meter reads. [Slowly move the magnet over the coil several times, noting the reading on the meter.]

Now, let's try moving the magnet faster. [Move magnet quickly.] I produce more electricity when I move the magnet faster, don't I? That's because I'm putting more mechanical energy into the magnet when I move it quickly.

Can you think of anything else that might affect the amount of electricity produced? How about the strength of the magnet? Here I have a smaller magnet. Let's see what happens when I move



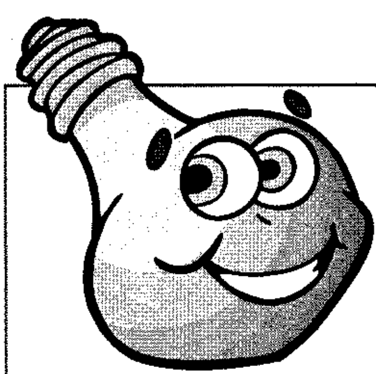
Above: *This illustration show how coal is burned to make electricity.*

both magnets at the same speed. [Demonstrate with both magnets several times, trying to keep your speed the same.] The larger one produces more electricity. So a stronger magnet produces more electricity.

There's another thing that can affect the amount of electricity produced – the number of turns in the coil. I have two coils here, one with many more turns than the other. [Let the audience examine both coils.] Let's try the experiment again. [Demonstrate using both coils.] The coil with more turns produces more electricity, even though it's smaller.

Today, we've learned that we can make electrical energy using mechanical energy to move a magnet across a coil of copper wire. We've also learned that the strength of the magnet, the speed of the magnet, and the number of turns in the coil all affect the amount of electricity produced.

Do you have any questions?



Here's an IDEA...

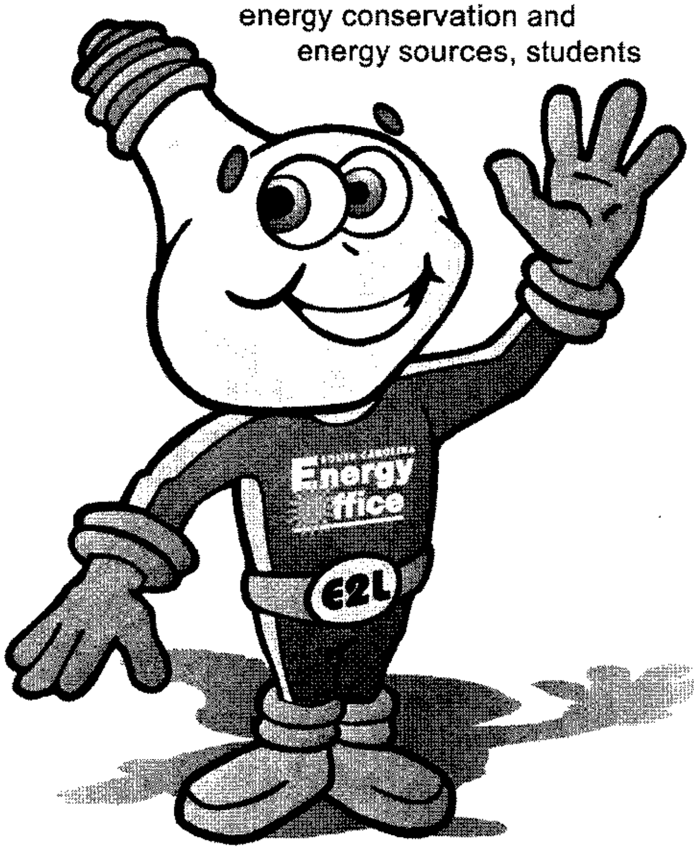
Ask adults for information about your project, but DO THE WORK YOURSELF!

'Energy 2 Learn'

"The Science Fair Project Guidebook: A Resource for Students and Parents" is part of "Energy 2 Learn," a comprehensive energy education program for South Carolina's students and teachers. "Energy 2 Learn" includes:

- **"Action for a cleaner tomorrow: A South Carolina Environmental Curriculum Supplement:"** This kindergarten through 12th grade curriculum supplement has air, recycling and water lessons as well as 10 energy lessons that provide not only a global and national perspective on energy, but South Carolina-specific information as well. Teachers can receive a copy or CD-ROM of "Action" following a FREE three-hour workshop.

- **Palmetto Energy Awards Program:** PEAP is a special program for K-6 students designed to help them learn about energy and how it affects their everyday lives. By completing teacher-approved projects on energy conservation and energy sources, students will earn points toward winning different awards. PEAP can be done in individual classrooms or the entire school.



- **South Carolina/National Energy Education Development Project:** The National Energy Education Development Project is a nationally recognized energy education program dedicated to developing innovative educational materials and training programs for teachers and students. NEED materials and training programs are designed to provide comprehensive, objective information on the scientific concepts of energy and the major energy sources.

- **"Energy 2 Learn" - The Summer Workshop:** Every summer a workshop is offered to teachers statewide to provide the latest information and educational materials on energy and other environmental issues, including, air, recycling and water. Admission is free, but spaces are limited.

- **"The Energy Factbook: A Resource for South Carolina:"** The Factbook provides an overview of energy with chapters on energy basics, fossil fuels, nuclear energy, electricity, solar energy, energy conservation and energy efficiency. The Factbook is available at no cost to teachers and students.

All program materials are available at no cost to teachers, schools or students. Teachers are welcomed and encouraged to use any or all of the programs offered. "Energy 2 Learn" offers balanced, objective and multi-sided information and materials, providing South Carolina's teachers and students with one of the nation's most comprehensive energy education programs. "Energy 2 Learn" is provided by a cooperative education partnership between the S.C. Energy Office and the S.C. Department of Health and Environmental Control's Office of Solid Waste Reduction and Recycling.

More Useful Information...

ENERGY MEASUREMENT EQUIVALENTS

1 ton	2,000 pounds
1 barrel (oil)	42 gallons, or 5.6 cubic feet
1 watt	A metric unit of electrical power; the product of voltage and current
1,000 watts	1 kilowatt
1,000 kilowatts	1 megawatt
1 kilowatt hour	1000 watts of power used for one hour of time; equals 3,413 Btus
1,000 kilowatt hours	1 megawatt hour
1 quad	one quadrillion Btus
1 MW (megawatt)	1,000 kW (kilowatts)
1 Btu	Quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit
1,000 Btus	1 kBtu
1 therm	100,000 Btus
1 CCF	1,030,000 Btus
1 gallon	3.785 liters
1 MBTU	1,000,000 Btus
1 ST (Short Ton)	2,000 pounds
1 mcf	.0971 therms

ABBREVIATIONS

bbl	1 barrel (oil)
ccf	100 cubic feet
MW	megawatt
MMbtu	1 million Btus
kw	kilowatt
Btu	British thermal unit
kwh	kilowatt hour
kBtu	1,000 Btus
mcf	1,000 cubic feet
ST	short ton

ENERGY CONVERSION STATISTICS

Carbon dioxide emissions for 1 kWh	1.5 lbs.
Coal required to produce 1 kWh	1 lb.
Average U.S. cost of 1 kWh	8 cents
Average annual gallons of gasoline used per car	500 gallons
Average annual heat savings using 1 low-flow shower head	466 kWh
Average annual water savings using 1 low-flow shower head	14,000 gallons
Average annual savings using 1 faucet aerator	4,000 gallons
Average annual savings using 1 set of toilet dams	5,475 gallons

BTU CONVERSION FACTORS

FUEL TYPE	BTUS
Electricity (Kilowatt Hours) (Site)	3,413
Electricity (Kilowatt Hours) (Source)	11,600
Natural gas (MCF)	1,030,000
Fuel Oil (No. 2) - gallon	138,400
Fuel Oil (No. 6) - gallon	153,600
LPG (liquified propane) - gallon	95,475
Coal (standard short ton)	24,500,000
1 kilowatt hour	11,000
1 barrel of oil	6,250,000

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Energy Office
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